Green House Gas Emissions from Agriculture and the Canadian Commitment to Kyoto

A Policy Issue Paper Prepared for the Agriculture and Agri-Food Climate Change Table

By the

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I. Introduction

The Kyoto Protocol

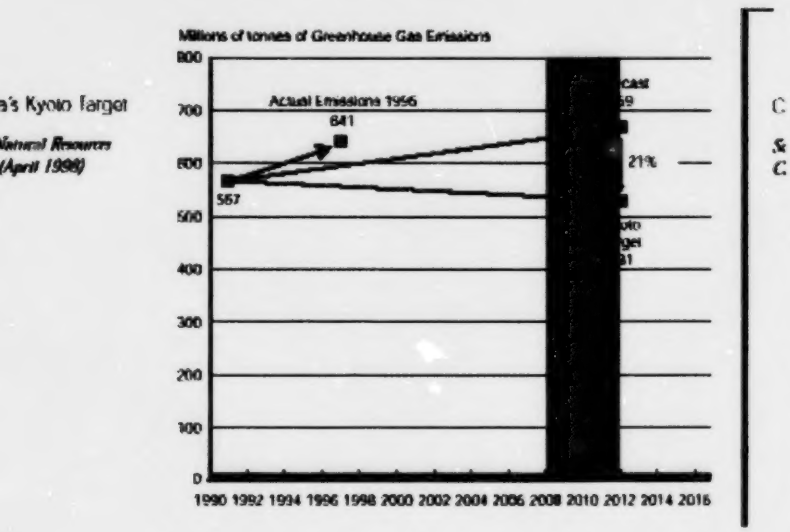
The Kyoto Protocol (Kyoto Protocol to the United Nations Framework Convention on Climate Change) is the result of a consensus among the nations of the world that climate change caused by human activities is a definite risk and that concrete action must be taken (IISD 1998). The treaty goes beyond the voluntary emissions characteristic of previous international agreements and is legally binding with compliance measures to be determined at future negotiations.

The treaty is a recognition by the world's major industrial nations that the scientific evidence for climate change is so strong, that it can no longer be ignored. Multinational corporations are adopting this view acknowledging that that they must move "beyond denial". John Browne, Group CEO of British Petroleum, in a speech on the treaty's implications stated "There's a growing consensus that climate change is an issue we have to take seriously" (IISD 1998).

In 1995, the United Nation's panel on climate change (IPCC) concluded that 'there is a discernable human influence on global climate." Jim Bruce, a scientist with the Canadian Climate Board, suggests that the clearest evidence of this change is the changing chemical composition of the earth" atmosphere. Since the Industrial Revolution, the concentration of carbon dioxide in the atmosphere has risen by 30 percent. Over the past few decades, scientists have measured a warming trend in the earth's surface temperature and predict it will accelerate unless action is taken now to reduce the rate of increase of greenhouse gases (IISD 1998).

Canada has agreed to reduce its greenhouse gas emissions by six percent from 1990 levels by 2008-2012. In order to meet our commitment under the Kyoto Protocol we will have to actually reduce greenhouse gas emissions by 21-25 percent over the next 14 years (Figure 1).

Figure 1: Canada's Kyoto Target



Source: Natural Resources Canada (April 1998)

Agriculture and Greenhouse Gas Emissions

Agriculture's contribution to GHG emissions is small compared to industry, nonetheless it is still considered significant (IPCC 1995, Bunyard 1996). This impact can be attributed to the intensification of agriculture since the Second World War, with fewer people working on the land there has led to a greater energy input in terms of fossil fuels and chemicals while livestock stocking rates have greatly increased (Bunyard 1996).

Bunyard (1996) reports that worldwide, agriculture is responsible for approximately one quarter of anthropogenic carbon dioxide emissions, nearly 60 per cent of methane emissions and up to 80 percent of nitrous oxide emissions. Sources include methane release as a result of biomass burning. Ruminant emissions, especially in developed countries, also contribute to methane. Heavy inputs of artificial fertilizers also add considerably to the levels of nitrous oxide – which has a radiative forcing equivalent some 200 times more than carbon dioxide as a greenhouse gas in the atmosphere (IPCC 1996). At least ten percent of the nitrogen applied every year to farmland as fertilizer evaporates directly to the atmosphere (Bunyard 1996).

In addition to these sources is the loss of sinks of greenhouse gases when land use is changed to provide for agricultural activities. The conversion of possible sinks such as forests, grasslands and wetlands to agricultural lands has led to the loss of potential carbon sequestering sites for

example.

As a source of greenhouse gases it will be incumbent upon the agricultural sector to contribute to Canada's commitment to the Kyoto Protocol through the following approaches identified within the treaty:

Carbon Sinks: Removing carbon dioxide from the atmosphere through the use of carbon sinks.

Clean Development Mechanisms (CDM) and Joint Implementation: The CDMs provide an incentive for industrialized countries to invest in initiatives in developing countries that reduce greenhouse gas emissions. Under the CDM the savings in carbon dioxide emissions will be recorded as a credit, which will be shared among the parties to the transaction.

Emissions Trading: The Protocol permits the trading of emissions among countries. It provides for countries with commitments under the treaty to buy and sell units of emission reduction among themselves.

II. What do we know?

In Canada, in 1995,emissions from agricultural sources contributed about 4 percent of the total greenhouse gas emissions, with a decline in these emissions during the period of 1990 to 1995 (Environment Canada 1997). The major sources were estimated to be enteric fermentation, 55 percent, agricultural soils, 24 percent, and manure 21 percent.

Enteric Fermentation

Methane production from herbivores as a by-product of enteric fermentation – a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream – defines this category (Environment Canada 1997). This process results in methanogenesis in the rumen which is emitted by eructation and exhalation. Some methane is released later in the digestive process by flatulation. Recent advances in animal

genetics and feeding practices have reduced emission rates per animal, however, as populations grow and milk and beef production increase, so do emissions of methane. Although both ruminant (e.g. cattle, sheep) and non-ruminant (e.g. pigs, horses) animals produce methane, however the ruminants are the largest source per unit of feed intake (Environment Canada 1997).

Manure

The emission of methane from manure has been estimated by using the methodology outlined by Cassada and Safley (1990, as cited by Environment Canada 1997). The emission factors have, however, been modified based on consultations with sector experts in Canada. The values for volatile solids and methane production are presented in Table.1, Emission Factors for Livestock and Manure.

Methane Emissions

Enteric fermentation (emissions from ruminant animals) is a large source of methane in Canada's national inventory (Environment Canada 1997). Emissions from animal wastes are also among the larger sources of methane. Enteric fermentation and animal wastes together contributed about 27 percent of Canada's methane emissions in 1995 (Environment Canada 1997).

Over the 1990 to 1995 period, methane emissions have been increasing in direct correlation to animal populations. Over the period 1992 to 1995, emissions of methane from livestock increased as did livestock populations (Environment Canada 1997). Only Ontario and the Atlantic provinces showed decline a decline in cattle populations, however an overall increase of 15 percent has been observed nationally, resulting in a net increase of approximately 12 percent in emissions over the period 1990 to 11995 (Environment Canada 1997).
However, much of this shift is as a result of changes in land management practices, such as zero or minimum tillage approaches, while emissions from livestock/manure and fertilizer use have increased 33 percent and 23 percent respectively during that same time period (Environment Canada 1997).

Emission Factors for Livestock and Manure

	Methane Production (kg/head/year)	Volatile Solids Production (kt/year)	Methane production Factors (kg/kv VS)
Horses	13	Not Reported	Not reported
Mules	Not Reported	Not Reported	Not Reported
Cattle			
Bulls	92	1103.8	0.011
Dairy Cows	105	2260.5	0.019
Beef Cows	56	1103.8	.0011
Dairy heifers	62	2260.5	0.019
Beef heifers	52	1103.8	0.011
Heifers for Slaughter	41	1103.8	0.011
Steers	44	1103.8	0.011
Calves	29	1103.8	0.011
Pigs			
Boars	3.3	561.5	0.043
Sows	3.3	561.5	0.043
Pigs (<20kg)	0.9	140.3	0.044
Pigs (20-60kg)	1.4	140.3	0.044
Pigs>60 kg)	1.9	140.3	0.044
Other Livestock			
Sheep	8.4	338.8	0.019
Lambs	5.6	338.8	0.019
Goats	7.8	Not Reported	Not Reported
Poultry			
Chickens	0.002	5.6	0.024
Hens	0.013	7.9	0.018
Turkeys	0.010	22.6	0.019

Table 1: Emission Factors for Livestock and Manure

Source: Cassada and Safley 1990 (as cited by Environment Canada 1997).

Agricultural Soils

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Agricultural Soils

In order to develop an estimate of carbon dioxide emissions from agricultural soils, a computer

modeling approach, the Century model (Parton et al. 1987), has been selected and applied by Agriculture and Agri-Food Canada. This mode was chosen as it adequately reflects the diverse and myriad complexities affecting carbon fluxes in agricultural soils (Environment Canada 1997). It contains input for multiple soil organic matter (SOM) compartments, estimates decomposition rates that vary as a function of soil temperature and precipitation, and provides data for both carbon and nitrogen flows.

The Century model takes several agricultural management practices into account, including planting, fertilizer application, tillage, grazing and organic matter addition. Several data sources are required to fulfill the extensive requirements of the model. Statistics Canada agricultural census data, on a Soil Landscape of Canada (SLC) polygon basis, were used to obtain crop cover and percentage of conventional and no-tillage figures for census years. Yearly crop coverage from 1990 to 1996 was taken from Statistics Canada core data. Soil data were derived from the Canadian Soil Information System (Can SIS), and recent fertilizer consumption and tillage practices were derived from the Farm Income Policy and Programs Directorate of Agriculture and Agri-Food Canada. Based on these inputs, the Century model was used to determine annual estimates for the period 1990 to 1996 (Environment Canada 1997).

These estimates are presented in Table 2, emission Trends for Agricultural Soils, and show a decrease in carbon dioxide from1990 to 1996. The Century model results indicate that the trend in the net emissions is towards an overall state of equilibrium of carbon in Canadian soils, which is predicted to occur in 1997. The rate of decrease in carbon dioxide emissions over the period 1990 to 1996 is about five times greater than the period 1980 to 1990, reflecting the changes in agricultural practices that have brought about these gins (Environment Canada 1997).

The introduction of no-tillage and less summer fallow in many areas of Canada, as well as more fertilizer application in the fertilizer application in the prairie provinces from 1990 to 1996,have led to a decline in the loss of soil organic matter (Environment Canada 1997). While the overall trend for Canada is towards carbon stabilization, some areas of the country show a slightly

different trend. For example, Ontario lost carbon dioxide from agricultural soils over the 1990 to 1996 period because of a substantial decrease in fertilizer application (Environment Canada 1997).

Emission Trends for Agricultural Soils

Year	Carbon Dioxide (kt)	Nitrous oxide (kt)
1990	7,090	11
1991	5,820	11
1992	5,000	12
1993	3,940	13
1994	3,490	13
1995	2,480	13

Table 2: Emission Trends for Agricultural Soils

Source: Environment Canada 1997

Fertilizer Application

Nitrous oxide can be released from soils under anaerobic or aerobic conditions. Liberation of nitrous oxide from soils is associated with the oxidation of mineral nitrogen. When either organic or inorganic nitrogen fertilizers are applied, most of the nitrogen is oxidized to nitrates before plants take it up. This oxidation process is known as nitrification.

If soils become anaerobic, facultative anaerobic bacteria can reduce the nitrates to nitrous oxide, which can be further reduced to N_2 before it is lost to the atmosphere. This process is called denitrification. The amount of nitrous oxide formed depends on a number of soil factors, such as oxygen supply, water content, temperature, structure, organic matter content and nitrate concentration. Most of the sampling periods used to generate the nitrous oxide emissions from fertilizers in Canada were less than one year, therefore the estimates of total annual atmospheric emissions might be low. On the other hand, the estimates of emissions of nitrous oxide from the

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application of anhydrous ammonia are probably high because the application rates in Canada are generally low. More research is necessary to improve the estimates. Table 3 summarizes nitrogen fertilizer use and resulting emissions in 1995. These emissions have been estimated based on the work of the Canadian Fertilizer Institute (CFI) Provincial estimates of emissions were based on emissions provided by CFI for 1990, prorated against national consumption data for subsequent years.

Fertilizer Material	Quantity (Tonnes)	N Content (Tonnes)	Average Loss (% N)	N20 (Tonnes)
Nitrogen				
Urea	1,304,730	600,176	0.11	1,037
Ammonia Sulphate	205,330	43,119	0.12	81
Ammonium nitrate	256,697	87,957	0.26	359
Anhydrous Ammonia	553,727	442,581	1.63	11,336
Nitrogen Solutions	232,908	66,029	0.11	114
Other nitrogen	3,199	0	0.11	0
Calcium Ammonium Nitrate	32,849	8,470	0.03	4
Phosphate				
Monammonium Phosphate	937,031	103,073	0.12	194
Diammonium Phosphate	180,785	32,541	0.12	61
10-34-0	1,705	238	0.11	0
Other fertilizers	293,804	64,171	0.11	111
Totals	**4,002,765**	**1,448,335**		**13,300**

Table 3: Fertilizer Use and Related N_2O Emissions (1995)

Source: Environment Canada 1997.

Energy Consumption

Energy consumption is the largest source of greenhouse gas emissions in Canada. The agricultural sector's dependency on the use of machinery, and fuels for transportation and heating means that the sector contributes significantly to the emission of greenhouse gases. Raw materials move to producers and their product in turn is transported to markets. Carbon dioxide

emissions dominate the energy sector accounting for 89 percent of the 1995 emissions (Environment Canada 1997). Specifically fuel consumption in the agriculture sector includes traction vehicles, pump fuel use, grain drying, horticultural greenhouses and other agriculture –related fuel use (Environment Canda1997). It is interesting to compare trends in fuel consumption emissions for the agricultural sector with the average annual temperature statistics over the same period. Although definite conclusions are difficult to make, during the period from 1980 to 1995 the trend has been toward greater fuel consumption with occasional peaks, possibly due to harsh winters (Environment Canada 1997).

In summary, agricultural activities contribute to the emissions of greenhouse gas and therefore the sector will have responsibility and opportunity to contribute to attempts at reducing these emissions.

III. What are the gaps?

Many of the gaps associated with working toward the reduction of greenhouse gases are associated with the development of baseline data, quantification of emissions from all sources and research that compares various practices and their impacts on emissions.

More research needs to be carried out regarding the effect of diet on ruminant sources of greenhouse gases. The effectiveness of zero and low-till practices needs to be determined and quantified. Models need to be refined, which can only be done by gaining more accurate data which is the basis of these tools. As has been mentioned, more research is necessary to improve the estimates of greenhouse gas emissions as related to the various types of fertilizers used, and techniques and timing of applications. Energy consumption specific to agricultural activities must be determined.

Techniques to measure the effectiveness of greenhouse gas sinks must be determined in order to provide for validation of emission reduction approaches to provide for crediting and trading

practices.

Once the baseline can be established and emissions accurately determined, policy development would need to provide for opportunities to respond to the need to reduce emissions. This can be done by encouraging changes in agricultural practices, reducing dependency upon fossil fuels, and providing for opportunities to diversify in response to climatic change.

Bruce et al. (1998) identified several research needs and issues. Their findings included a general need to improve estimates of carbon sequestration in soils and develop a means of determining "verifiable change in stock". However, specific efforts were recommended on the following topics:

A refinement of existing models is required so that they may be applied at region scales. This includes the need to improve modeling of physiochemical and biological processes in the soil and, in the short term, improve existing models.

There is a need for better information on present and historic land uses as drivers of change in soil carbon.

A better understanding of potential effects of a changing climate on plant production.

In order to validate models and assess impacts of measures, more extensive site networks and data sets are required.

More extensive and reliable information on soil degradation by different processes, its severity, and extent, as estimated through critical soil property indicators in various ecoregions.

Improved assessments of the impact of practices intermediate between no-till and intensive tillage and of intermittent use of conservation tillage and related practices. Improved

understanding of rates over time of carbon sequestration after introduction of revised management practices.

Development of innovative practices for deep placement of carbon and other measures.

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